

Claims:

1. A pipe structure comprising a flexible pipe connected to an end fitting, the flexible pipe comprising an armour layer and an underlying pipe layer to said armour layer, said underlying pipe layer having an outer surface around which armouring wires of an armouring layer are wound, the flexible pipe having a longitudinal axis wherein said end fitting comprises
 - 5 one or more anchoring elements adapted for anchoring at least one of said armouring wires, and
 - 10 a support unit arranged coaxially around said underlying pipe layer
 - at least one of said armouring wires comprising
 - 15 a conforming-wire-pipe-section forming a helical path and conforming to the outer surface of said underlying pipe layer of said flexible pipe at least over a part of its length, and
 - a wire-end-fitting-section,
 - said two wire sections extending in opposite directions from a wire-pipe-exit-point where said armouring wire separates tangentially away from said underlying pipe layer, and
 - 20 said wire follows an essentially straight line of a length L_{free} between said wire-pipe-exit-point and a straight-line-end-point on said support unit, said essentially straight line part of the wire being defined as the straight-line-section.
2. A pipe structure according to claim 1 wherein said wire-end-fitting-section is arranged to follow a predefined termination path between said wire-pipe-exit-point and one of said anchoring elements when said pipe structure is in an unloaded condition.
3. A pipe structure according to claim 1 or 2 wherein said straight-line-section is essentially unsupported between said wire-pipe-exit-point and said straight-line-end-point on said support unit.
4. A pipe structure according to any one of the preceding claims wherein said straight-line-section extends away from said longitudinal axis when viewed from said wire-pipe-exit-point.

5. A pipe structure according to any one of the preceding claims wherein said straight-line-section of said armouring wire has a tangential point of contact with said support unit in said straight-line-end-point.

5 6. A pipe structure according to any one of the preceding claims wherein said underlying pipe layer of said flexible pipe comprises an armouring reinforcement on a section of the pipe structure including said wire-pipe-exit-point and extending in a direction of the end fitting as defined by a direction from the flexible pipe towards the end fitting.

10 7. A pipe structure according to any one of claims 2-6 wherein said predefined termination path further comprises a supported-wire-section running on the outer surface of said support unit from said straight-line-end-point to a support-unit-exit-point where the armouring wire leaves the surface of said support unit for being locked in one of said anchoring elements, said supported-wire-section essentially constituting a geodetic curve between said straight-line-end-point and said support-unit-exit-point on said outer surface of said support unit.

15 8. A pipe structure according to any one of the preceding claims wherein the support unit comprises elements arranged to receive individual armouring wires.

20 9. A pipe structure according to claim 8 wherein the supporting surface of said support unit where said straight-line-end-point is located is individually formed for different wires having their straight-line-end-point located on said support unit.

25 10. A pipe structure according to claim 9 wherein the supporting surface of a wire is a single curved surface oriented normal to the pipe tangent plane of the wire, containing the said straight-line-section of said wire.

30 11. A pipe structure according to any one of the preceding claims wherein said support unit has an outer surface that describes a surface of revolution with an axis of revolution that coincides with the longitudinal axis of the flexible pipe.

35 12. A pipe structure according to any one of the preceding claims wherein said support unit has an outer surface which includes a part of a torus on which the straight-line-end-point is located.

13. A pipe structure according to any one of the preceding claims wherein said support unit has a convex part with an outer surface with an outward curvature and said straight-line-end-point is located on said convex part of the support unit.

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14. A pipe structure according any one of the preceding claims wherein said support unit comprises at least a first and a second body, said first body of the support unit has an outer surface which includes a part of a torus, and said second body has an outer surface that describes a surface of revolution, both surfaces having the same axis of revolution, said axis coinciding with the longitudinal axis of the flexible pipe, and both surfaces having coinciding tangents in a joining point in a cross sectional plane including the axis of revolution.

15. A pipe structure according to claim 14 wherein said second body comprises guiding elements for guiding armouring wires received from said first body.

16. A pipe structure according to any one of the preceding claims wherein said anchoring elements for locking said armouring wires to said end-fitting are distributed on one or more terminating parts.

17. A pipe structure according to claim 16 wherein the flexible pipe comprises more than one armouring layer and separate support units and terminating parts are allocated to each layer.

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18. A pipe structure according to any one of the preceding claims wherein said straight-line-section of an armouring wire is surrounded by a material which does not substantially alter the deformation behaviour of the flexible pipe and the wire.

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19. A pipe structure according to any one of the preceding claims wherein the flexible pipe is an un-bonded flexible pipe, preferably comprising a tube formed liquid tight inner liner and one or more armour layers, preferably two or more armour layers.

20. A pipe structure according to any one of the preceding claims wherein said flexible pipe comprises two layers of helically wound armouring wires, the winding angles with respect to the longitudinal direction of the flexible pipe being between 50 and 60 degrees, such as between 53 and 56 degrees, said armour layers 5 preferably comprising helically wound wires which are wound in opposite directions.

21. A pipe structure according to any one of the preceding claims wherein said armouring wire or wires are made of a composite material, said composite material preferably comprise one or more polymers, such as epoxy, thermoplastic 10 and polyurethane, optionally comprising reinforcing fillers such as fibres and/or whiskers.

22. A pipe structure according to any one of the preceding claims wherein said armouring wire or wires are in the form of a layered wire comprising 2 or more 15 layers of materials which may be identical or different from each other.

23. A pipe structure according to claim 22 wherein said armour layers of the wire or wires are made from one or more of the materials selected from the group 20 consisting of metals, such as steel, thermoplastic polymers such as polyurethane and thermosetting polymers such as epoxy, said polymeric materials optionally comprise reinforcing fillers such as fibres and/or whiskers.

24. A pipe structure according to any one of the preceding claims wherein said armouring wire or wires is/are in the form of a layered wire comprising 2 or 25 more layers of materials which layers being held together by a wrapping material and/or by adhesive forces.

25. A pipe structure according to any one of the preceding claims wherein the or each armour layer comprises one or two or a multitude of armouring wires. 30

26. A pipe structure according to any one of the preceding claims wherein said armouring wire(s) is/are flat, said wire or wires having a square formed cross section, optionally a square formed shape with rounded corners.

27. A pipe structure according to any one of the preceding claims wherein 35 each of the layers of the flexible pipe are fixed to said end-fitting.

28. A pipe structure according to any one of the preceding claims wherein said end-fitting comprises an axially extending through opening, said armouring wire or wires being supported by the outer surface of said support unit, wherein the outer 5 surface means the surface turning away from the axially extending through opening.

29. A pipe structure according to any one of the preceding claims wherein the armouring wire or wires is/are anchored by being embedded in a casting material, preferably in the form of a polymer such as an epoxy or a cementitious material.

10 30. A pipe structure according to any one of the preceding claims wherein the end-fitting comprises one or more locking cavities said armouring wire or wires is/are anchored in said locking cavity or cavities.

15 31. A pipe structure according to claim 30 wherein the armouring wire or wires being anchored by use of a spreader element driven into the wire or wires in said locking cavity or cavities.

20 32. A pipe structure according to claim 30 or 31 wherein at least one locking cavity has a length dimension defined as the length dimension of a wire mounted in the locking cavity, and the cross sectional area perpendicular to the length of the locking cavity differs along its length in one or more steps or continuously, wherein a first cross sectional area perpendicular to the length of the locking cavity is smaller, such as at least 5 % smaller, such as at least 30 % smaller 25 than a second cross sectional area perpendicular to the length of the locking cavity, wherein the first cross section is closer to the support unit than the second cross section.

30 33. A pipe structure according to claim 32 wherein the armouring wire or wires is/are anchored by use of a spreader element driven into the wire or wires in the part of said locking cavity or cavities where a first cross sectional area perpendicular to the length of the respective locking cavity is larger than a second cross sectional area perpendicular to the length of the respective locking cavity, the second cross section being taken closer to the support unit than the first.

34. A pipe structure according to any one of the preceding claims wherein the armouring wire or wires is/are anchored to the end-fitting by use of a spreader element driven into the wire to thereby spread the wire into two or more laminates whereby the laminated wire or wires is fixed against the wall or walls of a locking 5 cavity formed in the end-fitting.

35. A pipe structure according to any one of the preceding claims wherein the flexible pipe comprises two armour layers and the end fitting comprise two annular support units, the wire or wires of a first armour layer being supported by a 10 first annular support unit, and the wire or wires of a second armour layer being supported by a second annular support unit.

36. A pipe structure according to any one of the preceding claims wherein the pipe structure comprises a reinforcement sleeve layer placed below the one or 15 more armouring layer or layers, said reinforcement sleeve layer extend along the pipe structure in a length which include the section of the pipe structure between the wire-pipe-exit-point and the straight-line-end-point, said reinforcement sleeve preferably extend along the pipe structure in a length which include the anchoring point or points on the end-fitting.